

# Offshore Wind

## A European Perspective



August, 2019



**NY Power  
Authority**

## Executive Summary

The offshore wind market is playing an increasingly important role in the United States' energy discussions. The first US offshore wind project, the Block Island Wind Farm, launched operations off the coast of Rhode Island in 2016. Soon thereafter, States along the Northeast coast began proposing offshore wind goals of their own. It is now expected that they will generate a total of 19GW of offshore wind by 2035.

In contrast, European nations have already installed 18GW of offshore wind capacity over the past 20 years and are expected to reach a total of 70GW by 2028. For example, Denmark, the Netherlands, Germany and the United Kingdom are major players in offshore wind, with more than 16GW of offshore wind connected to their onshore grids. Each country, with its own unique geography and circumstances, followed its own particular path of development. There are, however, important lessons that should guide the continuing evolution of the US's offshore marketplace.

This study of offshore wind development in Europe was commissioned to review closely the more than two decades of experiences with this critically important source of renewable energy. This study

closely examined transmission and interconnection strategies, as well as other factors that enabled each country to lower its costs over time.

While there are an array of successful approaches to developing an offshore wind system, the following key takeaways should guide the development of the offshore wind industry in this country:

- The most effective path to low-cost wind power is through scale and healthy competition.
- The offshore transmission model used is dependent on a variety of physical and non-physical factors including geography. Regardless of model chosen, the coordination and incentive alignment between all parties is critical and needs to match their levels of respective capabilities.
- Visible, long-term grid planning on and offshore, removes barriers to entry, improves coordination and lowers costs.
- Cross-border coordination helps countries leverage planned transmission infrastructure, achieve resource flexibility and gain economies of scale.

## A Note from the President & CEO of The New York Power Authority

New York State (NYS) is making a bold commitment to building a clean, resilient and affordable energy system for all its residents and communities.

Through the recently passed Climate Leadership and Community Protection Act (CLCPA), the state mandated ambitious Green New Deal goals to decarbonize the energy sector and increase the share of renewable energy in the power generation mix:

CLCPA targets:

- Reduce energy-related greenhouse gas emissions by 85% relative to 1990 levels by 2050
- Increase the share of renewable energy in the electricity generation mix to 70% by 2030

Offshore wind (OSW), an essential part of this landmark initiative, is an important renewable source of energy that will help NYS achieve both of these goals. The waters off New York City and Long Island offer some of the best available wind resources in the world, putting New York in a prime position to support OSW development in the US.

In his 2017 State of the State Address, Governor Andrew M. Cuomo set a bold goal for NYS: to develop 2.4GW of OSW by 2030, enough to power 1.2 million homes. This target was expanded in the Governor's 2019 State of the State Address and mandated through the CLCPA to the installation of 9GW offshore wind by 2035.

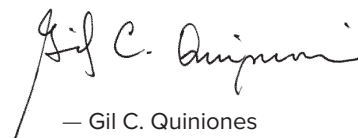
Since 2016, the New York State Energy Research & Development Authority (NYSERDA), working closely with communities, environmental advocates and other government agencies, has conducted 20 in-depth studies. They served as the basis for the Offshore Wind Master Plan, issued in January 2018, and established the strategy for meeting this new

OSW goal. This Plan is now moving ahead with the issuance of an initial request for proposal for OSW projects. Awards were recently announced for two offshore wind projects for a total of 1,700MW of OSW, representing the single largest renewable energy procurement by any state.

As we set out to meet this ambitious goal, NYPA, consulting with NYSERDA, New York Independent System Operator (NYISO), Long Island Power Authority (LIPA) and Con Edison, with additional input from National Grid, studied 20 years of European OSW transmission and interconnection project experience. Additionally, NYPA commissioned McKinsey to research the evolution of transmission and interconnection of OSW in Europe.

We thank our collaborators for their insightful thoughts and input during this process of investigation and analysis. This task cannot be done in a silo. We all must play a major part in supporting the State's clean energy goals, and each of our perspectives and roles will be crucial in addressing the various needs required to make OSW a success.

This is an exciting period for New York, its energy agencies, its private utilities, its offshore wind developers and its energy consumers. This report was designed to support Governor Cuomo's bold long-term clean energy vision and explicitly recognizes that offshore wind will play an integral role in achieving a new, renewable energy mix for the future.



— Gil C. Quinones

President and CEO of the New York Power Authority



**NY Power  
Authority**

# 1. Offshore Wind and Transmission: the US Context

Northeastern states, home to the most resource-rich waters for offshore wind, are actively proposing OSW goals. New Jersey and Massachusetts have both set ambitious goals of 3.5GW and 3.2GW of offshore wind by 2035, respectively. Connecticut and Rhode Island are also vying for OSW projects, and states further south, like Maryland and Virginia, are active in their pursuit of OSW projects, with California not too far behind. Collectively, Northeastern states have committed to over 19GW of installed capacity by 2035.

The region faces many important questions and challenges, as it strives to support the timely and efficient development of OSW. A particularly important issue is how to ensure affordability for consumers while spurring long-term economic development in each respective state. The answer will require mobilizing private investments and attracting the best OSW partners. As each state

contemplates how it will reach its goals, additional important questions will also include:

- How should transmission and interconnections be planned? Texas proactively planned transmission to accommodate renewables by designating a Competitive Renewable Energy Zone (CREZ). Is this proactive approach feasible for such a nascent and decentralized industry? Or would it be more prudent to plan as we go?
- What are the barriers in the US market to lower costs for the consumer?
- What type of offshore and onshore transmission configurations are best to accommodate rapid OSW growth?
- How do current transmission planning processes and regulations allow for more rapid planning of potentially large OSW injections onto the onshore systems?

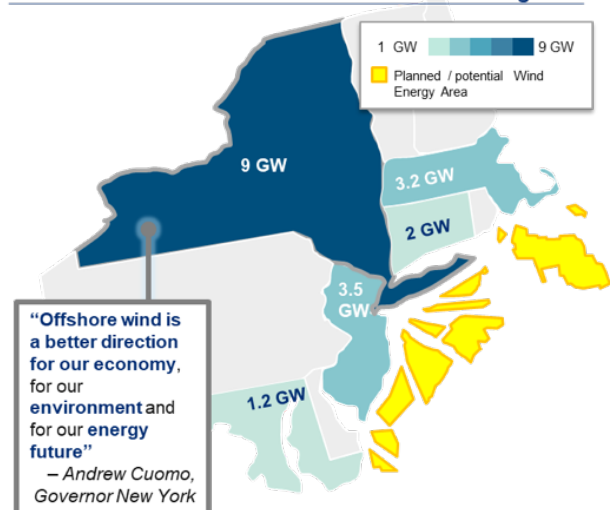
 ~17 GW of offshore wind (OSW) has been installed in Europe in the past decade, with **momentum now expected to spread to North America and Asia**. Key drivers are demand for low-carbon energy, decline in OSW costs and job opportunities

 Northeast states have announced commitments to a total of **~19GW of OSW**, with states expressing interest in **job creation opportunities**

 In the 2017 State of the State, Governor Cuomo announced a target of 2.4GW of OSW for NYS by 2030, citing opportunity for **\$6B of private and public infrastructure investment, and to create ~5,000 local jobs**

On July 18, 2019, Governor Cuomo signed the Climate Leadership and Community Protection Act mandating clean energy targets of the Green New Deal including 9 GW of OSW for NYS by 2035.

**Announced Northeast OSW commitments and targets<sup>1</sup>**



<sup>1</sup> Offshore Wind targets set by Maine and Ohio as well (not shown on map)

Source: NYSDERDA "New York State Area for Consideration for the Potential Locating of Offshore Wind Energy Areas", 4Coffshore, Press Search

**Exhibit 1: Contrasting NYS OSW target to neighboring states**

Offshore wind has been developing in Europe for the past 20 years. With 18GW of installed OSW capacity and an expected total of 70GW by 2028, the experience of relevant countries will provide important insights as the US ramps up its OSW efforts.

This study was conducted to gain lessons from the European experience with a focus on the transmission and interconnection of OSW. From this research, primary takeaways were summarized to serve as insights as further development is pursued in the US. Since the study took a deep dive into the four most active countries with OSW, it is important to understand some key differences between the European and US energy markets. While both markets provide similar services and share similar objectives, there are structural differences in how these markets operate.

In Europe, the Transmission System Operator (TSO) is an entity that is responsible for the

development, operation and maintenance of the infrastructure that transports electricity from the generator to the distribution system operators. TSOs can be and, in a few countries, are owned by the government. The public sector's main priority is maintaining a secure and reliable grid. Regulation of TSOs differ, with each country having its own regulatory body. It should also be noted that the European Union (EU) has an overall regulatory body that sets the guidelines for all the TSOs.

In the US, there is no direct equivalent of a TSO, as the transmission systems are planned, built, owned, operated and regulated by multiple entities at local, state and federal levels. These entities can include, but are not limited to, the following entities: the Independent System Operator or Regional Transmission Operator, transmission owners, utilities, state public commissions and the Federal Energy Regulatory Commission.

## 2. Understanding Offshore Wind Development Support

This study conducted an in-depth assessment of offshore wind developments in four leading European countries: Denmark, Germany, the Netherlands, and the United Kingdom. The analysis is based on extensive market research and interviews with leading developers and Transmission System Operators (TSOs) in these countries.

The study breaks down the evolution of OSW development in each country along five dimensions:

- Site Development
- Remuneration
- Offshore transmission design
- Offshore transmission ownership
- Onshore grid planning and cost allocation

These five dimensions provide a simplified—yet holistic—way to categorize and understand different OSW support design choices, and provide us with key takeaways.

### 2.1. Site Development

Site development is the initial assessment and development work for potential future offshore wind farms. Factors include wind resource assessment, sea bed surveys, environmental surveys (e.g., geotechnical, geophysical, marine biodiversity assessments), permitting, and authorizations (e.g., grid connection to shore).



There are basically two different site development models:

- **Developer-led:** Initial site development activities are performed by the developers; sites are typically leased by developers, which carry the cost and risk of initial site development.
- **Centrally led:** Initial site development activities are done centrally by one or more regulatory entities. Sites are initially not allocated to a specific developer. The government carries the cost and risk of initial site development and would typically auction the pre-developed site to developers at a later stage.

## 2.2. Remuneration

Three primary remuneration models have been used to reward developers investing in the development and operation of OSW projects:

- **Feed-in Tariffs (FiT):** OSW power producers receive a fixed tariff per MWh produced and are granted to all eligible power producers, independent of wholesale energy prices.
- **Green certificate:** OSW power producers receive 'green certificates' per MWh produced, which can be traded. Typically, electricity suppliers (e.g. utility) must purchase a certain share of certificates for their supply business. Falling short of the required amount results in fines that are distributed amongst certificate holders.
- **Power purchase agreements (PPAs):** OSW power producers are compensated for the difference between wholesale prices and a certain strike price (PPA price). Competitive RFPs are typically used to determine the strike price of PPAs. PPAs allow a variety of payment structures and terms (e.g., floor prices, ceiling prices, inflation adjustments, full load hour limits, contract duration limits, etc.).

## 2.3. Offshore transmission system design

OSW project transmission systems can be designed either in a radial or networked architecture:

- **Radial:** Each wind farm project has its own grid connection directly to shore—these are typically AC connections.

- **Network:** Multiple wind farm projects in the same area are connected through a network to one or several shared offshore substations with a shared export infrastructure (one or several export cables). Often (but not always) DC technology is chosen for shared export infrastructure.

## 2.4. Offshore transmission system ownership

There are three distinct offshore transmission system ownership models utilized by OSW projects in the four European countries studied:

- **Transmission System Operator (TSO) owned:** Under this model, the TSO is responsible for planning and building the offshore grid connection, as well as operating and maintaining it. Offshore wind connections are typically planned as a part of an integrated grid plan.
- **Developer owned:** Here the developer is responsible for offshore grid planning and construction, as well as operations and maintenance.
- **Third party-owned:** In order to drive competition, this model separates the power generator (developer) from the transmission asset (from the project to onshore connection). While the developer may plan and construct the transmission, at commercial operation, the transmission asset is competitively bid to a third party to own, operate and maintain. The separate entity does not necessarily build the grid connection.

## 2.5. Onshore grid planning and cost allocation

Coordinating off-and onshore grid developments and allocating grid upgrade costs are critical items of any successful OSW development process. TSOs always play a coordination role, ensuring that onshore grid developments are coordinated with offshore connections. The main difference between countries is how costs are allocated and shared. Three onshore grid cost-sharing models can be identified:

- **Grid upgrade costs fully passed through to rate payers:** All onshore grid reinforcements and expansion required to accommodate offshore wind are socialized with rate payers.



- All grid upgrade costs paid by individual generator: All onshore grid reinforcements and expansion costs required are covered by the generator who's request to connect is triggering the upgrades.
- Directly attributable grid upgrade costs paid by individual generator: Only directly attributable onshore grid reinforcements and expansion costs required are covered by the generator, whose request to connect is triggering the upgrades. Upgrades triggered by individual generation assets, yet benefit the entire system will not be

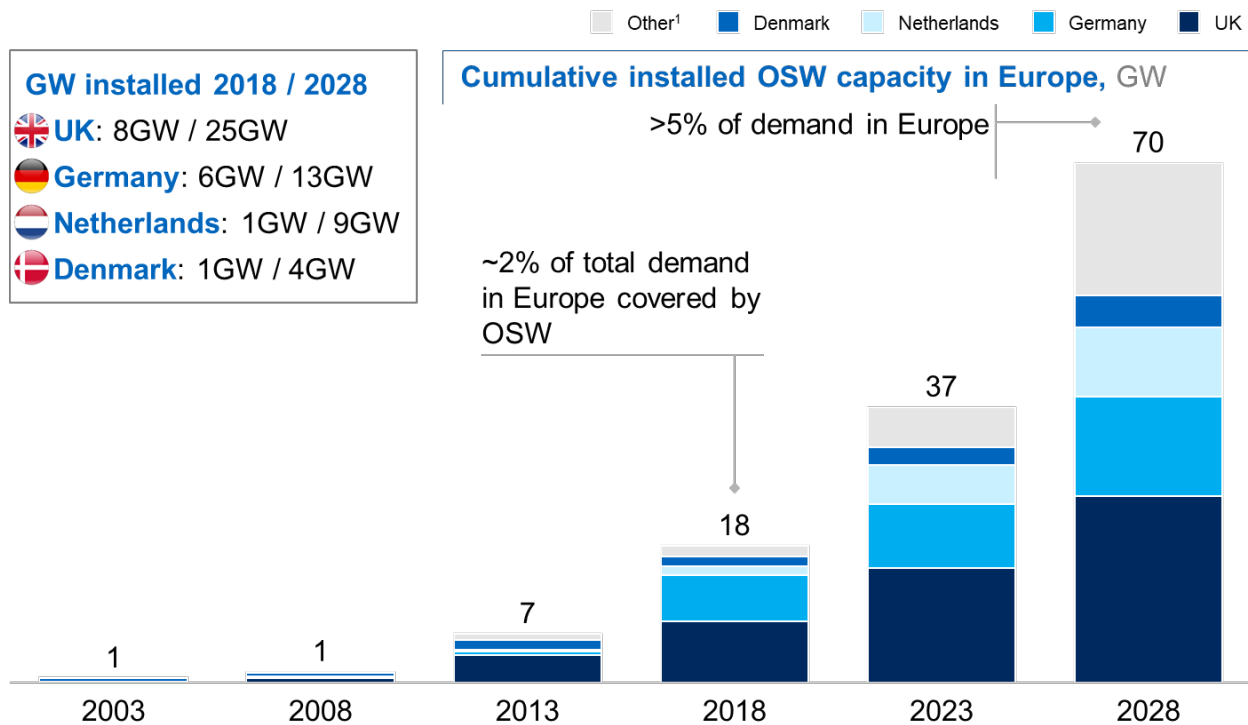
directly allocated to the connecting generator. It will instead be socialized among the generators. This model is utilized in the UK.

In the next section, the decisions of the different European countries are contrasted along each dimension. These companies will help answer two core questions:

- Which design choices were made?
- What were the implications of these choices on OSW development?

### 3. Lessons Learned from European Experiences

OSW installed capacity in Europe is expected to increase four-fold over ten years from ~18GW installed in 2018 to ~70GW in 2028. Four countries account for the bulk of the OSW market and are the focus of this study: the United Kingdom, Germany, the Netherlands, and Denmark.



<sup>1</sup> Other includes remainder of EU countries, Norway and Turkey

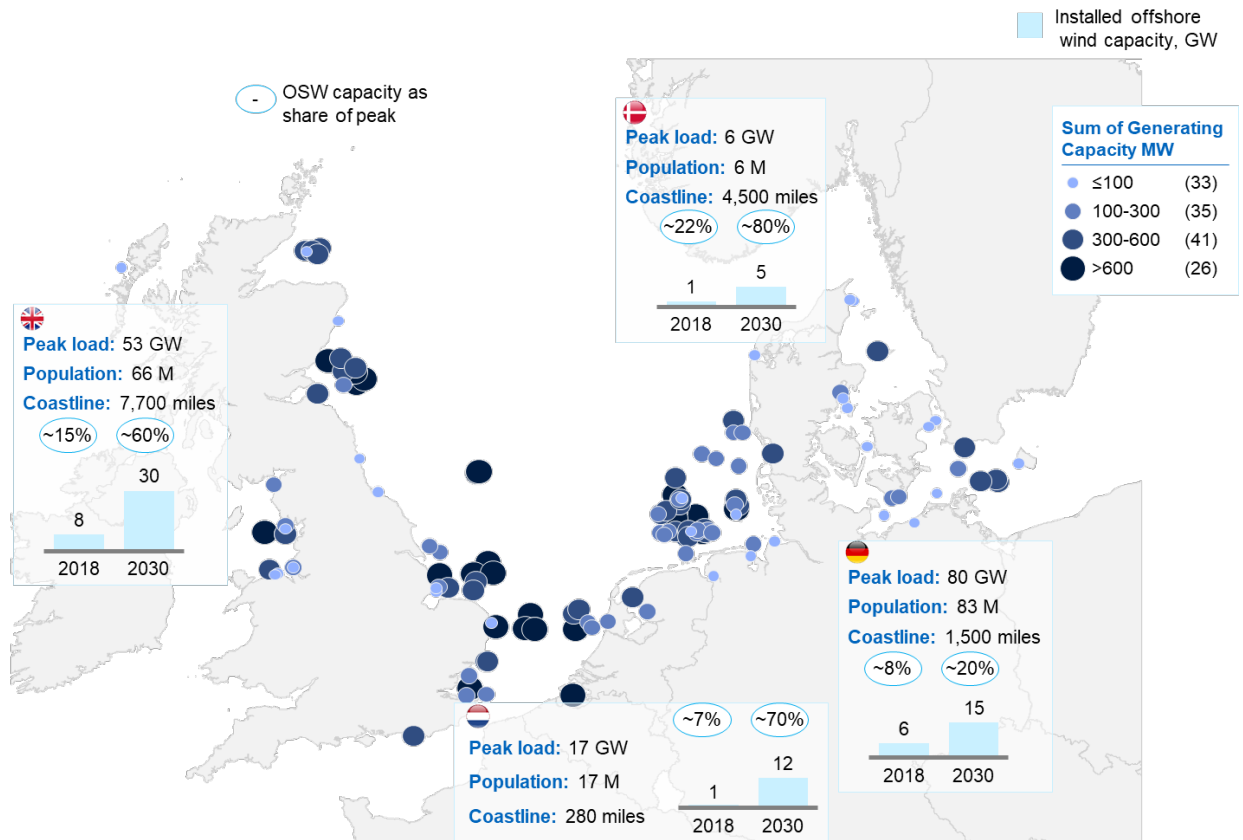
Source: ENTSO-E Scenario Report; Wood Mackenzie Power & Renewables: Wind Market Outlook Update Q2/2019; 4COffshore

**Exhibit 2:** Evolution of European OSW installed capacity



These four countries have different geographic characteristics:

- From the small (Denmark: 6M people, 6GW peak load) to the populous (Germany: 83M people, 80GW peak load)
- Coastlines from the constrained (Netherlands: 280 miles) to the expansive (UK: 7,700 miles)



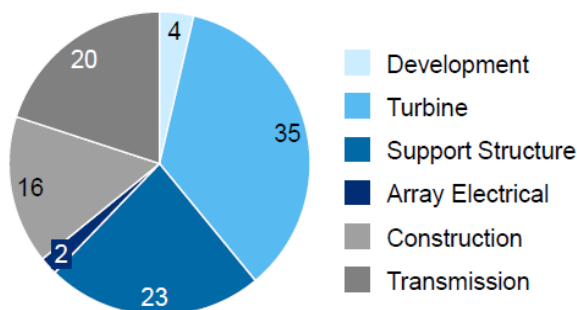
1 Includes operational, awarded, planned, and announced projects (not all shown projects are guaranteed to be built)

**Exhibit 3:** Overview of offshore wind projects in Europe



Today the investment cost of an average European offshore windfarm is roughly 4M EUR/MW driven primarily by turbines (~35%), foundations and other support structures (~20%), transmission (~25%), and development/construction (~20%).

**CAPEX breakdown of offshore wind farm,**  
% of total



**Sample project economics of baseline wind farm** with following characteristics

- 40 km from shore
- 35 m deep water
- 10 m/s wind speed
- 500 MW Farm Size
- 6MW turbines

**Transmission costs vary significantly across projects** usually accounting for between 15-30% of total costs according to water depth, distance from shore, etc.

Source: Crown Estate; NREL; InnoEnergy: "Future renewable energy costs: Offshore wind"; Team analysis

**Exhibit 4:** Indicative breakdown OSW investment costs in Europe

Operational expenditures are roughly ¼ of lifecycle costs at ~70k EUR / MW / year, with the bulk coming from offshore logistics (crew boats, jack-up vessels and survey vessels), technicians, spare-parts and onshore support.

Across these countries, the cost of OSW has come down significantly over time. This result has been driven in large part by technology development, improved operational efficiency and industry maturation, as well as increasing competition and reduced margins across the value chain. A large share of the cost reductions can be attributed to the introduction of ever larger wind turbines (from typical 3.6MW/107m rotor turbines during the early 2010s to the current and upcoming 7-12 MW/154-220m rotor turbines), which significantly lower the

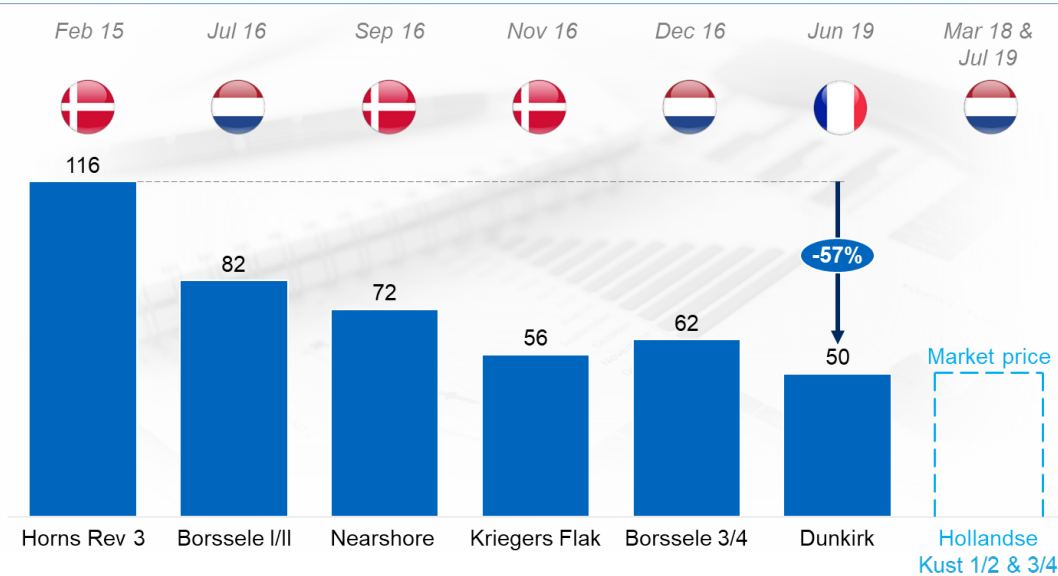
relative share of installation, balance of plant and operations and maintenance costs.

From a rate payer perspective, costs have been cut by more than 50% over the last five years in each of the four markets. This leads to "subsidy free" PPA's from offshore wind developments in Germany and the Netherlands (excluding offshore transmission costs, which are covered by rate payers) or close to current wholesale electricity prices (UK—including offshore transmission cost; Denmark—excluding offshore transmission cost).

Recent auction results in the US and in Taiwan (which have come in close to European cost levels) underline that the technology development and industry maturation can be transferred to a large degree across markets.

### Successful offshore wind bids – all projects exclude transmission scope, USD/MWh<sup>1</sup>

#### Bid date

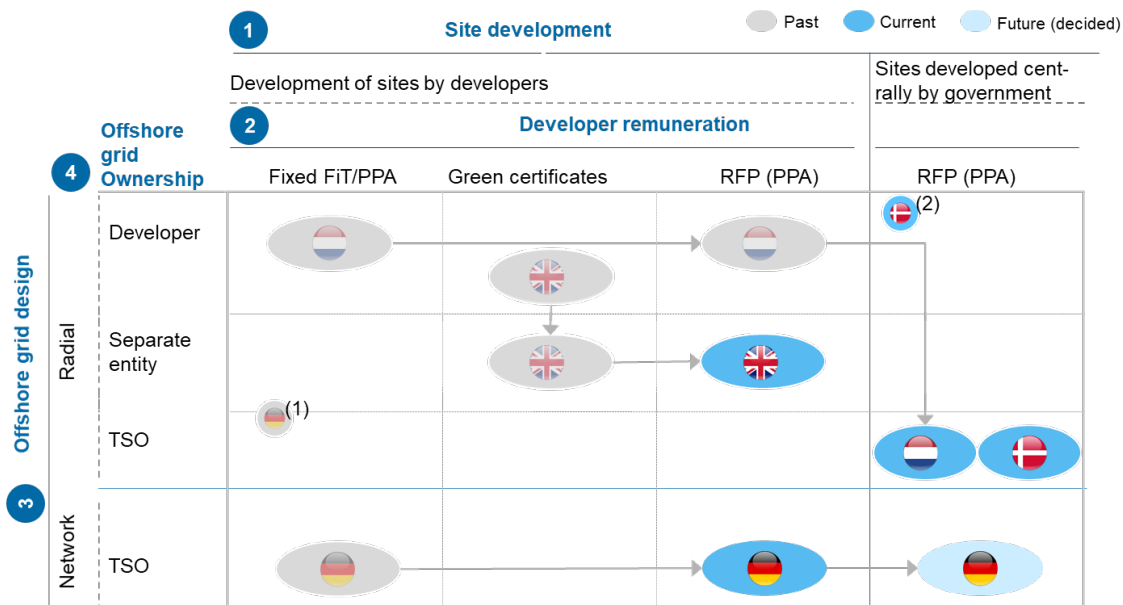


<sup>1</sup> Based on average exchange rate in June 2019 (1 EUR = 1,1293 USD); grid connection only included in scope at Danish nearshore project Vesterhav  
SOURCE: Published RFP results; ECB

#### Exhibit 5: Evolution of winning bids in Europe

### 3.1. How did leading European countries support OSW development?

The study of OSW in the respective four European markets summarized in Exhibit 6, shows that there is not a single approach. Each country has charted its own path, often influenced by localized factors, combining different design choices and invariably evolving them over time.



Source: Energinet; TenneT; National Grid; International Energy Agency

#### Exhibit 6: Evolution of OSW support models in Europe

### 3.1.1. Denmark

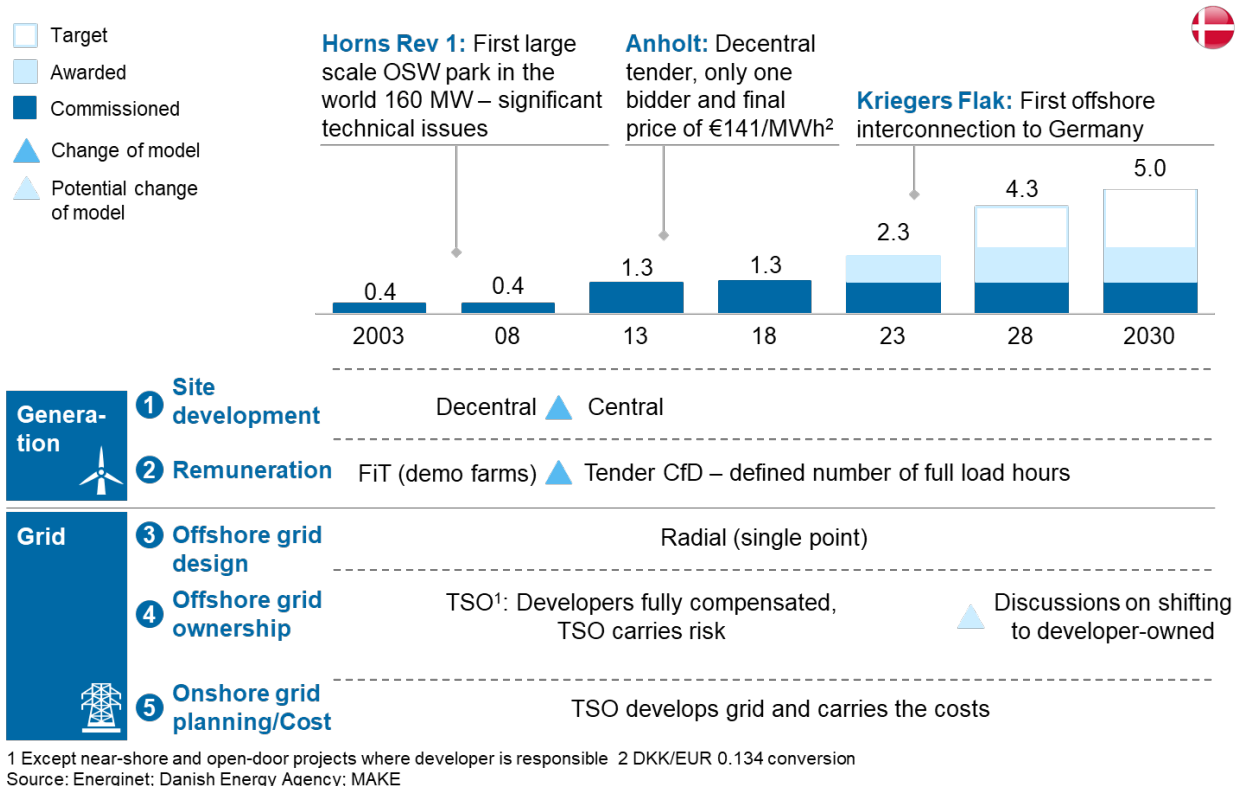


Denmark was the first mover in the offshore wind market globally and targets 5GW of installed capacity by 2030, representing about 80% of the country's peak load. Despite a relatively small local power market, it is home to key players like the developer, Ørsted, and the turbine manufacturer, Vestas.

Denmark's regulatory framework has remained stable over the last decade, allowing the Danish government to establish long-term plans for OSW development. The OSW sites are centrally developed and then opened to independent developers through PPA auctions. Denmark is the only major market to use tenders as the primary remuneration mechanism from the onset, leading

to relatively low bid prices. Transmission is also developed centrally by the TSO, Energinet, which provides the offshore substation and is responsible for connection and integration of the project onto the onshore grid. As part of those responsibilities, Energinet also fully compensates the developer in case of delays or outages and ensures the onshore grid can integrate offshore wind.

As other countries have copied the Danish model of centrally led site development and TSO-built offshore grid, Denmark is looking to evolve further. It is currently considering transitioning away from the TSO-built offshore grid to one that is developer-owned. They are also contemplating issuing specific transmission tenders to further drive competition and lower costs.



**Exhibit 7:** Summary of OSW support in Denmark

### 3.1.2. United Kingdom

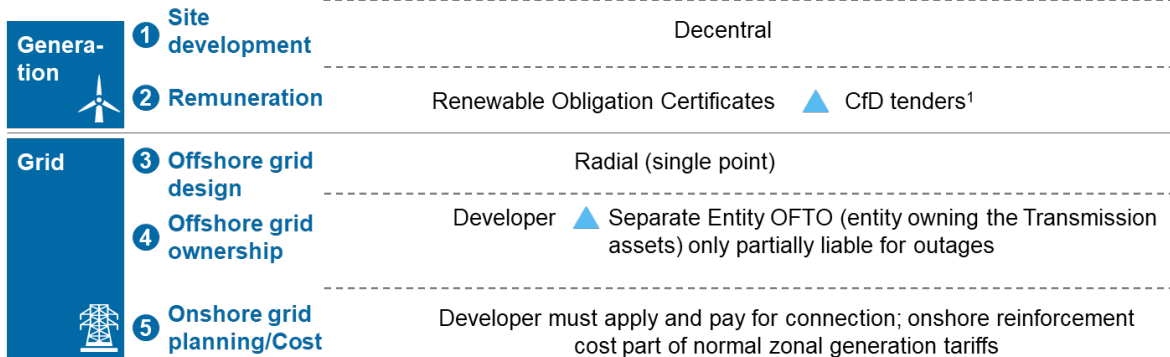
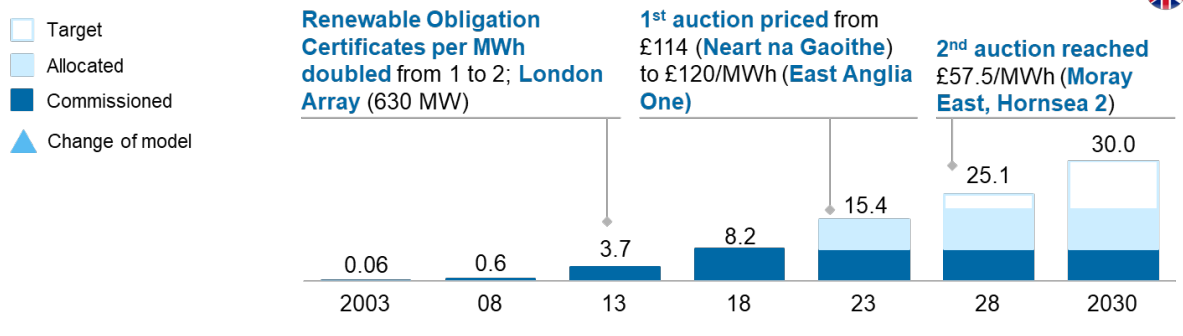


The United Kingdom is the world's largest OSW market with plans to expand from 8GW in 2018 to 30GW in 2030 (about 60% of peak load). The UK's long shoreline has eased grid integration for multiple OSW areas.

Site and project development remains developer-driven. Onshore grid connection is centrally coordinated by the TSO, National Grid Electricity Transmission (NGET). In this case, the developer must apply and pay for offshore connection to shore. NGET owns and operates the onshore grid and is responsible for planning and identifying transmission upgrades needed to accommodate OSW connections. To recover costs associated with transmission system upgrades, NGET will propose charges applied through a Transmission Network Use of System charge, which requires approval from the Office of Gas and Electricity Markets (Ofgem), the regulator.

Offshore transmission system ownership in the UK is ThirdParty Owned. While the transmission asset is usually built by the developer, by law, the developer must sell the transmission asset to a Third-Party Offshore Transmission Owner (OFTO) via a competitive solicitation run by a separate regulator, Ofgem. OFTOs are competitively licensed to operate transmission assets by Ofgem. Under this arrangement, the OFTO's also only carry a small portion of the outage risk as penalties for transmission delays. Additionally, outages are capped at 10% of OFTO revenue.

Remuneration for UK projects has changed from Renewables Obligation Certificates (ROCs) to PPA auctions. Zero subsidy bids are not possible in the UK, in part due to the higher costs from developer-built transmission and how the UK structures its PPAs. The PPA price acts as a ceiling price, where if the market price of electricity was to be greater than the PPA price, the developer pays the difference.



<sup>1</sup> Transition until 2020 (expected commission year) with CfDs granted based on qualitative assessment  
Source: Ofgem; National Grid; MAKE

**Exhibit 8:** Summary of OSW support in the United Kingdom



**NY Power  
Authority**

### 3.1.3. Netherlands



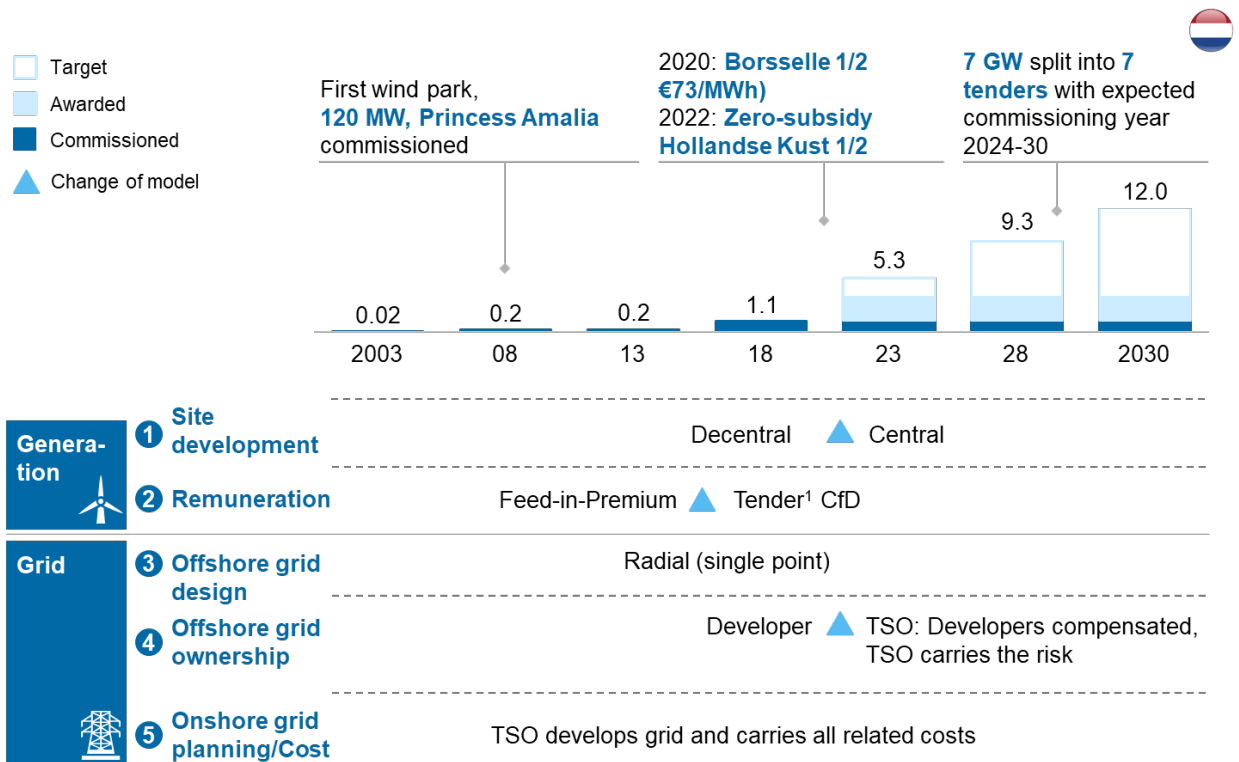
In 2018, the Netherlands had 1GW of OSW capacity and has set a target to reach 12GW by 2030 (fulfilling about 70% of peak load). The country is a second mover in OSW and has learned from the experiences of neighboring countries.

The Netherlands, following the Danish model of centrally developed OSW sites, provides long-term planning visibility to the market. Transmission system planning is done centrally by the Ministry of Economic Affairs and Climate Policy. The government owned TSO, TenneT, builds, maintains and operates the onshore grid. With respect to offshore transmission, TenneT is also responsible for providing developers with a connection point to the onshore grid via an offshore substation platform.

Over time, the Netherlands has utilized remuneration models from feed-in tariffs to auctioned PPAs with floors. Initially, the Netherlands used the developer-led model for site development. As long-term planning progressed, it transitioned to centrally developed sites in 2015.

Until 2021, new RFP's were issued for projects in increments of 700MW due to the standardized transmission systems built and administered by TenneT for the developers to connect their project to. Starting in 2021, the government plans to increase the size of the tenders to 1GW per year.

In order to further support climate policy goals, the Netherlands launched an idea to build a 30GW artificial wind island by 2027. While the output of this wind island would be much greater than the needs of the Netherlands, it can be deployed to multiple countries, allowing for more cost-effective transmission.



**Exhibit 9: Summary of OSW support in the Netherlands**

### 3.1.4. Germany



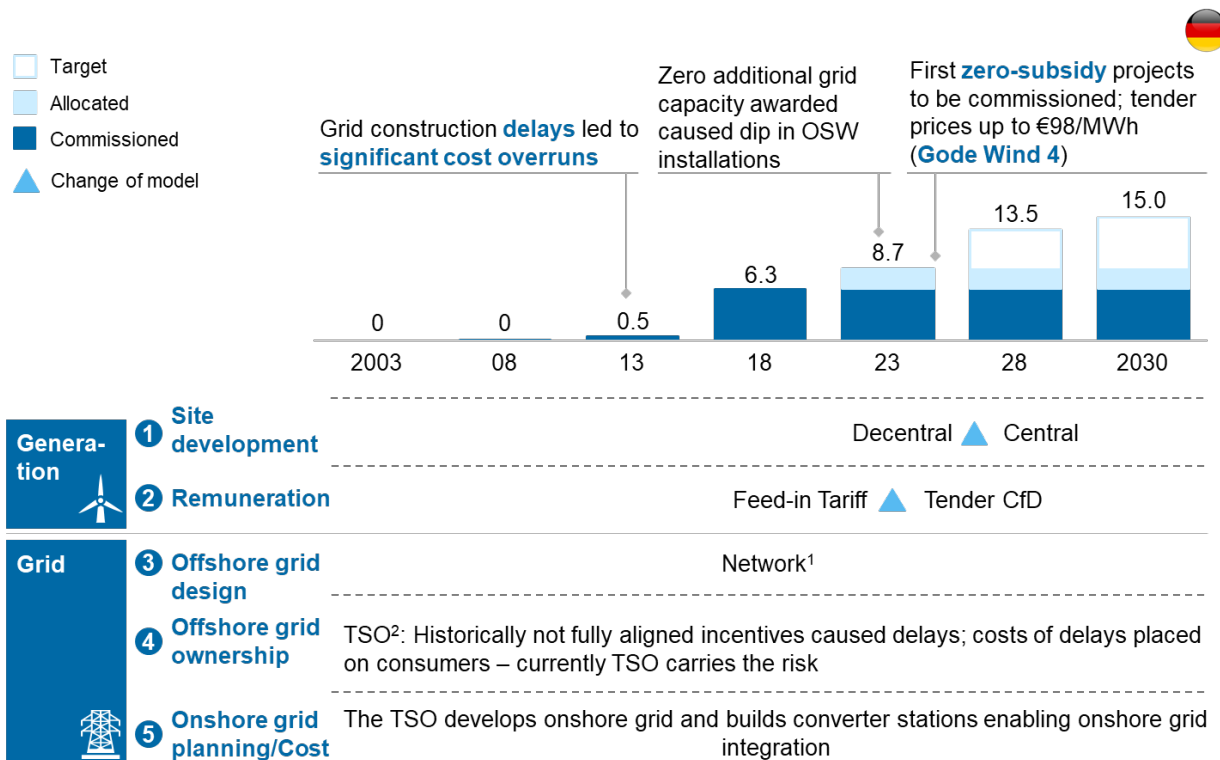
Despite being a late-mover, Germany is the second largest offshore wind market. The country has a target of 15GW by 2030 (about 20% peak load). OSW growth has some challenges in Germany due to constraints on the onshore grid system. The North-South transmission grid bottlenecks hinder the ability for OSW generated off the coast of Northern Germany to reach significantly larger volumes in the South. In order to accommodate additional OSW growth, a transmission project, SüdLink, is currently underway to strengthen onshore North-South transmission and better connect large power demand areas in the South to offshore resources in the North.

There are two TSOs involved with the grid development and planning for OSW in Germany. TenneT owns and operates the OSW grids in the North Sea and onshore grids across central

Germany. 50Hertz owns and operates OSW grids in the Baltic Sea and onshore grids in the North-East.

Of the four countries studied, Germany is the only country using a networked offshore grid. Germany has a relatively short shoreline and a networked grid helps minimize the number of cables running through environmentally sensitive marine areas near shore. The HVDC connection to shore is owned and managed by the TSO (TenneT or 50Hertz), while the AC offshore substations and connection to the converter station are owned by developers.

Germany started with developer-led sites, while the TSO was responsible to provide the developer with a connection to the grid. Due to technical issues and misalignment in risks and incentives between the developer and the TSO, there were long and costly grid delays that were ultimately borne by rate payers. Through regulatory reform,



<sup>1</sup> Selected minority of projects are radial <sup>2</sup> Developer owns offshore sub-station and AC export cable to converter  
Source: Federal Networks Agency; TenneT; 50Hertz; MAKE

**Exhibit 10:** Summary of OSW support in Germany



the offshore grid became an integrated part of the offshore area development plan in 2012, shifting site development to a more centrally led model. It also expanded the grid-planning process to be TSO lead, creating increased transparency and visibility for development. Under this re-developed model, the TSO will be liable for further generator compensations in case of lost production due to delays; better aligning risks between developers and the TSO.

Germany's remuneration model started with the use of feed-in tariffs and overtime has evolved into auctions with PPAs, resulting in zero-subsidy bids.

### **3.2. Distinguishing Design, Regulatory and Cost Differences between the European Models.**

#### **3.2.1. Site development**

Developer-led site development is typically faster than centrally led projects, as private actors have capabilities for quick deployment. There are also greater incentives to identify the best sites first and most effectively develop them.

In contrast, centrally led models tend to lower barriers of entry as the same information is made available to all, enabling more developers to compete. The model also supports a more end-to-end assessment of grid capacity, connectivity, and total system cost, as a central entity can plan and provide visibility for specific sites.

#### **3.2.2. Remuneration**

Denmark was an early adopter of PPA auctions. The three other countries studied have shifted to PPA auctions over time, whether from Feed-in Tariffs (Germany and Netherlands) or Green Certificates (UK).

Feed-in Tariffs played a particularly important role in Germany and the Netherlands to help establish a nascent industry by guaranteeing a stable price for OSW. In contrast, PPA auctions have led to more competitive pricing. This approach is well-suited once the industry has reached a certain level of maturity, as is the case in all four countries today. In the three countries that shifted to PPA auctions, as well as in Denmark (which had a system of PPA auctions all along), observed reductions in costs to rate payers were strong.

#### **3.2.3. Offshore transmission system design**

The UK, Denmark and the Netherlands all have radial grid connections for their OSW projects. Germany is the only European country to have adopted a truly networked grid model.

A network grid model may help achieve economies of scale in transmission if connecting multiple small projects. In Germany, it requires higher levels of coordination and planning among different projects. It may, therefore, lead to expensive overbuild of capacity or delay project execution.

In contrast, a radial grid model is simpler, easier to plan, size, and execute on a project-by-project basis. Even in the UK, with more than 7,000 miles of shoreline, the radial model is reaching saturation in interconnection points available for the projects.

The debate between radial versus networked grid architecture will continue to evolve as capabilities and technologies mature. Single projects in Europe are notably growing increasingly large, potentially reducing the rationale for building a networked transmission system in some instances.



### 3.2.4. Offshore transmission system ownership

The dominant European model is for TSOs to develop and own the offshore transmission grid. This is the case in Denmark with Energinet, the Netherlands with TenneT, and Germany with TenneT (North Sea) and 50Hertz (Baltic Sea). The UK is the only case study country to have adopted a different, Third-Party Ownership model, where developers build the transmission grid before being mandated to sell them to an independent Offshore Transmission Owner (OFTO).

As the European industry continues to mature there is still some debate as to the optimal offshore transmission system ownership model. Below is a synthesis of the most salient arguments put forth by developers and TSOs.

A TSO can optimize onshore and offshore grid development and is well-positioned to address other grid considerations, such as redundancy, and ancillary services. By managing several transmission assets, TSOs can transfer learnings from one offshore transmission project to the next while they typically also have access to relatively cheap capital, due to their strong balance sheets and credit ratings.

In addition, coordinating and reaping the synergies of generation and transmission asset construction is a complex task, which can be greatly facilitated if the same entity manages both generation and transmission projects.

Since TSOs are a single, usually government-owned, entity, it does not allow many opportunities for private transmission entities to participate in

the transmission market. Without the competitive pressures and incentives as developers may have, incentives for the TSO can potentially be misaligned.

Alignment of incentives during the operations phase, in the case of split transmission and generation ownership, is complex. Ensuring that the transmission owner carries the full cost of a potential grid-outage appears important to give the right incentives to invest in maintenance and fast failure resolution capabilities (e.g., spare cable sections on-site, fast mobilization of vessels).

### 3.2.5. Onshore grid planning and cost allocation

In all three markets where the TSO owns the OSW transmission assets (i.e., Denmark, Netherlands, Germany), it is also responsible for long-term grid planning, often in close coordination with the government. In these countries the costs are fully passed through to rate payers. In such a model, bid prices are reduced, as the scope and risks for developers are more limited. Consumers, however, carry all costs of grid expansions, including costs due to delays and outages.

In the UK, the TSO is also responsible for planning, but grants permission to developers to connect to the grid. Its decision is based on a central coordination process. Grid expansion costs are paid by the generators benefitting from the expansion and reduce the burden on customers. The process, however, renders long-term grid planning more difficult for the TSO due to decentralized generation planning and uncertainty in which projects will be built.

## 4. Key Takeaways from the European Experience

### **The most effective path to low cost wind power is through scale and healthy competition.**

In the last 20 years, over 18GW of Offshore Wind capacity has been installed in the UK, Denmark, Germany and the Netherlands. Yet, the offshore wind industry in Europe still offers no clear standard approach to infrastructure design, implementation and operation. Each country continues to explore different paths to low-cost wind power based on its particular regulatory and physical environment.

One fact is consistent across the four countries studied: As each country progressed through development, and as the market competition increased, all countries switched to more competitive tenders and PPAs in order to encourage more competition. The most effective path to low-cost wind power is through scale and healthy competition.

### **The offshore transmission model used is dependent on a variety of physical and non-physical factors including geography. Regardless of model chosen, the coordination and incentive alignment between all parties is critical and needs to match their levels of respective capabilities.**

Different shoreline geographies are certainly playing a role in how each country chooses the type of offshore transmission network. The UK, with over 7,000 miles of shoreline, makes it possible for each project to have its own connection to shore. Whereas Germany, with only 1,500 miles, has opted for a more networked option. While this enables Germany to develop more wind parks with minimal disturbance to the environmentally sensitive shoreline, it does present coordination, accountability and incentive alignment

challenges between the developer and the TSO. These challenges caused delays in implementation, ultimately burdening the consumer with the additional costs. In response to these challenges, Germany made a change to regulations creating a TSO lead grid planning process, eliminating delays.

In the UK, where the shoreline makes it conducive for the radial option, it is starting to see strains on the available interconnection points for projects. As it grows its OSW industry further, how to optimize those interconnection points to accommodate all projects will be the challenge.

### **Visible, long-term grid planning on and offshore, removes barriers to entry, improves coordination and lowers costs.**

Approach to grid planning is also playing an important role in determining costs and encouraging competition and scale. Denmark, the Netherlands and Germany now carry out centralized, long-term planning for siting, generation, transmission, interconnect and onshore transmission upgrades in an attempt to provide as much forward-looking visibility to developers, grid operators and other key stakeholders. The electricity system in each of these countries was not originally designed to integrate large quantities of offshore wind. This resulted in new stresses on the existing grid and potential bottlenecks. Providing greater visibility over the planning process is removing some of the barriers to entry for new developers. This is encouraging greater coordination between the developers and the TSOs, as well. This is particularly true when it comes to existing infrastructure upgrades and efficient use of interconnection points.



**Cross-border coordination helps countries leverage planned transmission infrastructure, achieve resource flexibility and gain economies of scale**

Finally, looking beyond the borders of individual countries, Europe is now exploring regional offshore wind opportunities in an effort to find new efficiencies that could help lower costs and meet climate goals. An example is the planned North Sea Wind Power Hub, sending wind-generated electricity via long distances to eight countries. Coordination between countries will help with

the likely challenges of renewable balancing and smoothing, while maximizing the use of resources without the risk of building overcapacity.

As the United States develops its OSW industry, it has much to learn from the experiences of the European countries examined in this study, which have explored many similar development issues in great depth. As the US becomes more aggressive in pursuing OSW, this analysis will provide greater insight into the many opportunities and challenges ahead for the energy marketplace of the coming decade and our efforts to combat climate change.

